

## DEVELOPMENT OF STRONGER AND MORE-RELIABLE CAST AUSTENITIC STAINLESS STEELS (H-SERIES) BASED ON SCIENTIFIC DESIGN METHODOLOGY

### BENEFITS

The high-strength compositions of H-Series steels resulting from this research along with the predicting capability of optimized compositions for the required mechanical properties will have a major impact in improving process efficiencies for the chemical, steel-processing, and heat-treating industries.

- ➔ Improved process efficiencies will result in significant savings in energy through reduced downtime of the production equipment, higher operating temperatures, reduced replacement of components, and increased productivity with reduced rejection.
- ➔ Estimated benefits include energy savings of over 35 trillion Btu/year and cost savings of \$185M/year by 2020.

### APPLICATIONS

The H-Series stainless steels have many applications in the **Chemical, Forest Products, Heat Treating, Petrochemical, and Steel** industries:

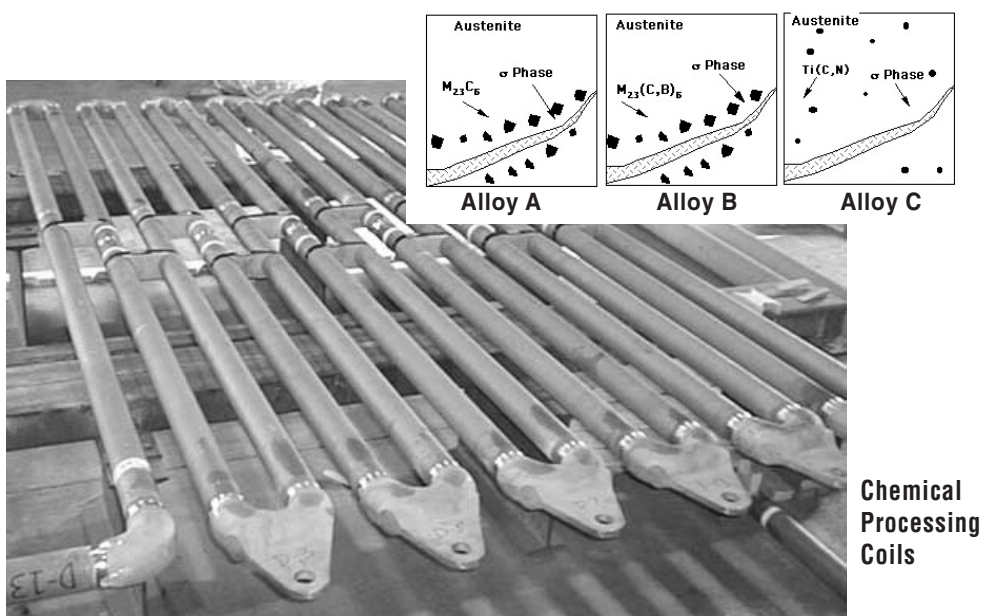
- ➔ Burner tubes for heat-treating furnaces.
- ➔ Transfer rolls for heat-treating furnaces.
- ➔ Coiler drums and rolls for Steckel mills.
- ➔ Tubes for ethylene cracking and other processes.

## HIGHER-STRENGTH H-SERIES STEELS WILL IMPROVE THE EFFICIENCY OF PROCESSES IN CHEMICAL, STEEL, AND HEAT- TREATING INDUSTRIES

The H-Series austenitic steels are used extensively in several industries for a broad range of high-temperature applications. The H-Series stainless steels have evolved over the last 80 years and have reached saturation levels in both their mechanical properties and their upper-use temperature.

The goal of this project is to increase the high-temperature creep strength by 50% and the upper-use temperature by 30 to 60°C for HP-modified and 100 to 200°C for modified HK cast austenitic stainless steels. The R&D will focus on the use of alloy design methods developed at the Oak Ridge National Laboratory (ORNL), based on precise micro characterization and identification of critical microstructure/properties relationships, and on combining them with the modern computational science-based tools that enable the prediction of phases, phase fractions, and phase compositions based on alloy compositions. The combined approach of micro characterization of phases and computational phase prediction will permit rapid improvement of a current class of alloy compositions with the long-term benefit of customizing alloys within grades for specific applications.

### Computational Modeling



## Project Description

**Goal:** The goal of the project is to increase the high-temperature strength by 50% and upper-use temperature by 30 to 60°C of H-Series cast austenitic stainless steels.

**Issues:** H-Series steels have evolved over the last 80 years. In most cases the improvements in strength have been obtained for specific applications by the addition of alloying elements based on production expertise. Such additions generally improve strength with side effects of generating sigma and other embrittling phases. Furthermore, such alloy addition effects work for a specific application but cannot be extrapolated to other operating conditions. The current alloys have reached a plateau with respect to their properties. This project will attempt to understand the material and additions by utilizing microcharacterization and modeling, which will allow for translation of effects across a broad range of operating conditions.

**Approach:** Three concepts will be used in the proposed approach:

**Task 1.** Conduct computational thermodynamic and kinetic modeling to identify the phases present in the as-cast compositions of HK steel and modified HP alloys. The same analysis will also be carried out on cast samples subjected to controlled thermal exposure in the laboratory and after service operating conditions.

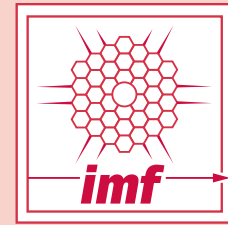
**Task 2.** Conduct micro characterization of the phases present and identification of critical microstructure/property relationship for the as-cast and exposed samples of HK and modified HP alloys. The outcome of this analysis will result in (a) verification of the phases predicted by the computational modeling; (b) identification of expected properties, which will be verified with the observed properties; and (c) development of new compositions for higher-strength versions of the HK and modified HP alloy.

**Task 3.** Prepare experimental-size cast alloys of the higher strength compositions designed from Tasks 1 and 2. Characterize the compositions for mechanical properties and thermal exposure and compare them with those of the predicted phases and properties.

**Potential payoff:** Components fabricated from the new H-Series steels would result in improved efficiencies for chemical processes such as ethylene cracking, steel processing longer-lasting components for steel heat-treating and heat-treating furnaces, such as long-life radiant burner tubes. This may result in energy savings of over 35 trillion Btu/year.

## Progress and Milestones

- ➔ Complete computational thermodynamic modeling of H-Series steels in the as-cast and thermally treated conditions.
- ➔ Complete micro characterization of compositions in the as-cast and thermally aged conditions.
- ➔ Complete experimental melting and casting of new compositions and their screening by performing stress relaxation tests.
- ➔ Complete melting of selected compositions in 500-lb heats and casting into centrifugal tubes for mechanical property testing.
- ➔ Complete development of software that correlates properties with compositions of H-Series steels.
- ➔ Complete fabrication, installation, and testing of components in commercial applications.



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